A STUDY ON SUPERFICIAL RINGWORM INFECTIONS

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The material for this thesis was collected in the Royal Navy during the years 1935-1939, and I am indebted to the Medical Director General for permission to use it in this way.

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The Pathological Department, St. John's Hospital for Diseases of the Skin, London, very kindly lent the clinical photograph to illustrate Chapter 3, and most of the material in the microphotographs came from the same source. The actual microphotography was done by the Wellcome Bureau of Scientific Investigation, and I am indebted to them for their unfailing helpfulness.

Plates 1 and 2 are from the collection of Dr. F. Reiss of Shanghai, and infected scales were supplied from his clinic for photography. They were photographed through the courtesy of Schmidt & Co., of Shanghai.

Access to references was greatly facilitated by the ungrudging co-operation of Mr. T.J. Shields, British Medical Association Librarian. Without his help this thesis would have been impossible. I am grateful to him for all the assistance he has so efficiently rendered. I am also indebted to the librarians of the Leeds Medical School, and the Lester Institute for Medical Research, Shanghai.

At various periods the chapters in this thesis have been published elsewhere, and copyrights have been returned through the kindness of: The British Medical Journal; The Journal of Tropical

Medicine and Hygiene; and The Journal of the Royal Naval Medical Service.

To the foreign students of London University who helped with the translation of references I express my thanks. Without material reward and prompted only by friendliness towards a fellow-student, they gave freely of their time, in what must have appeared to them, an incomprehensible investigation.

Lastly, I wish to apologise to those of my cases to whom I promised undying fame in the annals of medicine in exchange for their feet. I doubt if they will recognise themselves in the groups of figures. However, their co-operation was essential, and I trust I am forgiven this mild deceit.

CHAPTER ONE

Introduction.

There are numerous fungi pathogenic to man, fortunately most of them of tropical or subtropical occurrence, and it is proposed in this thesis to deal only with the varieties responsible for superficial infections of the skin, with special reference to the feet. The causative organisms, in most cases, are species of the genera trichophyton and epidermophyton, and it is rare in this country to obtain cultures outside these genera. Ringworm of the scalp, and the comparatively infrequent yeast infections do not come within the scope of this contribution.

From reports on mycotic dermatoses it is obvious that the incidence of these conditions is showing an alarming upward trend. Analysis of this state of affairs reveals two factors of error: more frequent recognition of superficial lesions, and a too enthusiastic attitude in diagnosis. Despite these however, the increase appears to be actual, and the following table compiled from the 'Health of the Navy' publications bears this out:-

Table 1

	1930	1931	1932	1933	1934	1935	1936
Tinea (various forms)	72	65	101	110	142	238	311
Fresh cases	38031	42798	39284	41852	38652	37963	40278
Total strength	88840	87075	83285	83125	83240	86345	92245

It will be seen that the figures commence in 1930, that being the first year in which mycotic infections were separated from the bulk of skin diseases, and so far, the Navy is the only fighting service to have carried out this statistical refinement. Unfortunate :ly this table contains some unavoidable fallacies. To begin with, most ringworm lesions in the adult do not require hospitalisation, and cases treated on the attending list are not included in the tinea (various forms) or fresh cases columns. In addition, there may be one or two cases of tinea tonsurans from the cadet's college or boys' training establishments. Were the figures to include all fresh cases of superficial ringworm reporting for treatment, the incidence from year to year would be very much higher. So troublesome are these infections in hot countries that in 1936 a committee of surgeons from the Mediterranean Fleet was appointed to consider the question of prophylaxis and treatment on that station (MacEwan 1938).

Over a period of sixteen years C.J. White (1927) reported the following fresh cases seen in his private practice,

Table 2.

Year	Fresh cases of tinea.	Year	Fresh cases of tinea.
1910	3	1918	31
1911	5	1919	79
1912	11	1920	87
1913	14	1921	131
1914	20	1922	118
1915	17	1923	148
1916	21	1924	156
1917	25	1925	147

and Williams (1936) showed an upward trend in superficial mycoses

in Boston from 1926 to 1933. Reiss in Shanghai (1938) had 72 fresh cases of tinea pedis in 1934 and 273 in 1936 and the incidence of other superficial mycotic infections showed an upward though less marked tendency; while from Australia, reports indicate (Makin; Witton Flynn, 1935) that tinea pedis and cruris are becoming increas: :ingly common.

As we understand them, these infections are not usually disfiguring or disabling diseases, but in countries whose social services and hygienic standards are somewhat behind our own, gross and crippling deformities may result. The two plates reproduced below are from the collection of Dr. F. Reiss of Shanghai, and illustrate the relationship between chronic tinea pedis and recurrent erysipelas-like manifestations -

Plate 1

Chronic lymphoedema

Plate 2

Many do not agree with Allan's suggestion (1934) that this

condition is an allergic manifestation of fungus infection, but it has been pointed out (Reiss, 1938) that a chronic pedal lesion may well serve as a portal of entry for secondary organisms which may, in time, lead to a chronic lymphoedema. From a service point of view even a mild degree of secondary infection from a small mycotic focus may render a man unfit for duty, to say nothing of personal discomfort and pain.

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CHAPTER TWO.

The History of Superficial Ringworm Infections.

The study of fungi is as old as that of botany, but it was not until the nineteenth century in France that clinical mycology became recognized, although there are several mentions of parasitic moulds before that time.

The royal botanist, Hooke (Ed., 1934), in 1677 noted a parasitic fungus which caused discolouration on rose leaves, and shortly afterwards Malpighi wrote of vegetable parasites - "plants which grow on other plants" - as he called them. Then in 1729 Micheli described the genus aspergillus, and 23 years later the botanist, Linnaeus, in his 'Species Plantarum' collected and tabulated all the available knowledge of the fungi.

It was not till 1839, however, that Langenbeck discovered the first parasitic fungus of man, that of thrush, and in the same year Schönlein discovered favus. It is interesting to note that two years previously Remak had noticed mycelial filaments in favus but regarded them as secondary implantations. The next step was the discovery of ringworm in 1844 by Grüby. He described three ringworm fungi associated with as many types of lesion. Unfortunately, he caused considerable confusion by his clinical descriptions in which he mistakenly included typical examples of alopecia areata as cases of tinea. Naturally, other observers failed to find fungi in alopecia and his work fell into disrepute. Sabouraud later confirmed his findings and acknowledged the priority of his discovery. Four years after Grüby's publication, Malmstein found a fungus in ringworm

which he called a trichophyton, and the name trichophytosis was given to the condition it caused.

So far the study of ringworm had been limited to the scalp and beard regions, and the first departure was made by Dévergie in 1857, when he described eczema marginatum as a form of herpes circine. Hebra in 1860 gave a classical description of the condition, and what is extremely interesting in view of modern American statistics, mentioned its infrequent dissemination to the extremities. The causal factor was found four years later by Kobner, when he isolated fungal elements from eczema marginatum and proved their specificity by reproducing the disease experimentally.

The first mention of ringworm of the feet as a separate entity was made by Mouktar in 1892, when he found fungi in dermatitis of the soles. He followed Remak's error, however, and regarded the filaments as secondary contaminants, with the result that his observations passed unnoticed. Some time before this, in 1888, Zingale (1923) claims that Pellizari described ringworm as producing eczema of the feet. Thereafter, with the rapid and spectacular advance of bacteriology, and the more exact methods of culture and identification, mycology fell somewhat into disrepute.

The next advance did not follow till 1908, when Whitfield (1908) found fungi in six cases of vesicular and scaly eczema between the toes. This was the result of routine microscopic examination of all such cases in his practice. Two years later Sabouraud (1910) showed epidermophyton inguinale by culture in hand and foot lesions and in 1911, at a meeting of the Royal Society of Medicine, he and Whitfield presented papers on ringworm of the feet which drew universal attention to the condition.

From that time an increasing amount of confirmatory evidence has been forthcoming, although many important modifications have taken place.

In his original writings Sabouraud laid down that:-

(a) A given fungus always produces a constant clinical picture.

(b) Eczema marginatum is always due to epidermophyton inguinale, as are most foot lesions.

(c) A given fungus grown on his proof medium would always appear the same.

Ormsby and Mitchell (1916) and Rosenbaum (1923) have since shown that the same fungus may cause a variety of lesions, and various fungi may cause identical lesions. Weidman (1922, 1927), and Kurotchkin and Chen (1931), have practically reversed the position with regard to the incidence of e.inguinale in foot cases, although a lot seems to depend on locality. Kurotchkin thinks e.inguinale the commonest cause of tinea pedis in Europe while Reiss of Shanghai finds a trichophyton the most frequent offender in his practice. Table 9 chapter 5 shows the variety of fungi isolated from clinically identical cases in 1938.

The third postulate still holds good and forms the basis for identification of pathogenic fungi to-day. In his original medium Sabouraud used crude maltose (Chanut), but the factory for its manufacture was closed in 1896 (Sabouraud quoted Weidman and McMillan, 1921), although small quantities continued to appear on the market long after this (Mitchell, 1922). Substitute media were accordingly used, with the result that the widest cultural variations occurred. The position has now been universally cleared by the standardisation of growth on local media against original cultures

obtained chiefly from Sabouraud.

So prevalent has foot ringworm become in America, that in 1930 it was ranked by the dermatologists of that country (Lancet, 1930) as the commonest skin disease, far outstripping its nearest rival. It is said to have been brought to the United States by returning soldiers after the Great War. Gray (1926) considers it was introduced to Britain by returning Anglo-Indians.

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CHAPTER THREE

The Diagnosis of Superficial Ringworm Infections.

The medical profession, perhaps more so than any other, is susceptible to changes in fashion; and the growing awareness among the public of superficial ringworm infections, especially that variety known popularly as 'athlete's foot', may be in part responsible for the increase in the incidence of these conditions. In 1934 Gray (1934) drew attention to the problem presented by these pedal lesions, and later Wise and Wolf (1936) deprecated their too casual diagnosis.

The main difficulty in the recognition of mycotic infections is the frequent and early spontaneous disappearance of fungal mycelia from the infected area, and in late cases there may be nothing to distinguish the condition from dermatitis from other causes (Whitfield, 1908, 1911). The reason for this disappearance is hard to understand in view of the viability of the pathogenic fungi (Farley, 1921; Weidman, 1927; Bruhns, Alexander, and Kadisch, 1929), but the secondary bacterial contamination which sometimes occurs may in some way exert a lethal influence on the moulds, (Falchi, 1934). In this connexion the observations of Weidman (1926) on a case of pedal ringworm sown with yeasts are of importance. Thus it would appear that many cases of tinea, when seen, will not show the causal agent, although such authorities as J.H. Mitchell (1922) and C.J.White (1919, 1927) countenance a diagnosis on clinical grounds alone in the chronic keratotic pedal type. This may be admissible under certain circumstances, but the

demonstration of the specific factor still remains a 'sine qua non' in diagnosis, and the following statement by Ramsbottom (1931) may be taken as an expression of general opinion: "There is, however, a tendency on the part of some investigators to assume a fungal origin of a disease on insufficient evidence. It is not enough to postulate the parasitic nature of a disease and then, bacteria, protozoa, and other parasites being eliminated, to describe it as mycotic; the evidence must be as clear as that for any other parasitic group."

In addition it must be remembered that all cases of inter: :digital scaling and maceration are not mycotic, although von Graffenried (1918) and Catanei (1932) have shown that such lesions form a suitable nidus. Dirt seems to bear no relation to infection, as the highest incidence is to be found among the wealthy and more leisured classes (Beintema, 1931).

Nomenclature.

The outlook on mycotic infections has been further confused by the variety of terms used to designate similar conditions. By superficial ringworm is generally understood a lesion of the skin caused by a vegetable parasite; and, although at times the circinate arrangement is absent, the name has stood the test of time in this country. Tricophytosis and epidermophytosis are descriptive terms, and indicate the genus of the infecting fungus, but without recognition in culture, differentiation is impossible. Their somewhat elegant sound has led to considerable misuse, and despite the fact that in the minds of many they stand for a parasitic skin

condition of the extremities, the underlying cause is not fully appreciated. Incidentally the predominating genus seems to depend on geographical situation, and the table of the world's mycological flora by Weidman (1927) is of considerable interest in this connection.

Recently the American Dermatological Association has labelled infections of the extremities - dermatophytosis, and general infections, elsewhere - dermatomycosis. These descriptions are all-embracing, but they cannot be recommended for general use until a more scientific attitude towards mycological dermatology is adopted.

The term tinea still has a measure of usefulness, and the addition of the site localizes the disease, e.g. tinea pedis, tinea cruris, tinea barbæ, etc. Colloquialisms such as - Hong Kong foot, toe rot, mango toe, athlete's foot, and many others, should be left to the layman.

The Service nomenclature of these conditions is still notoriously vague and haphazard. In statistical returns they are variously designated mycotic infections, trichophytosis, pompholyx, and tinea, with the result that accurate statistical deductions are impossible. Universal use of tinea would do much to clear up this confusion.

Clinical Diagnosis.

Superficial ringworm is caused by infection of the upper layer of the epidermis by fungi of the genera trichophyton and epidermophyton. Other members of the family gymnoascacea (Stitt) may be implicated, but they are rare by comparison. Clinically the parasite shows a predilection for certain areas; the inter: :digital spaces, and the crural and axillary folds. Isolated patches

often occur on exposed sites from direct infection, frequently from animal sources. Such animal ringworms usually show a considerable pustular element. Apart from the feet, where moisture and maceration may modify the picture, the lesions are characterized by sharply demarcated, intensely itching, inflammatory areas with a healing centre. Minute vesicles will be found at the periphery where the inflammation is most marked (fig.1), and the pathogen can be recognized microscopically in scrapings from the spreading edge.

Fig.2 shows an area on the back of the neck which probably involves the hair. Hair infections are also seen in the beard region, but they are extremely uncommon in the Services. They can be diagnosed from the more common sycosis barbæ by the presence of mycelia, which may be scanty, and by the fact that in tinea barbæ there is always a nodular element present. It should be noted that the epidermophyton never affects the hair, and that ringworm of the scalp is a dermatological curiosity in European adults. In the Asiatic adult active tinea tonsurans of the large spore variety is a common occurrence.

Fig.3 illustrates a typical patch of tinea at a somewhat later stage but the cardinal features can still be made out.

Fig.4 is a good example of the common crural infection so frequently seen on tropical service. The spreading edge of this type of lesion is always loaded with fungi, and scales for examination can be picked off with fine forceps. Strangely enough the typical vesicular element is very seldom present in this location.

Differentiation must be made from intertrigo due to streptococci and yeasts, the flexural forms of seborrhœic

dermatitis and psoriasis, and erythrasma.

Streptococcal intertrigo is an impetigo of the flexures, and the characteristic vesicle edge can be made out at the margin of the lesion. Monilia infections can only be differentiated with certainty by culture, as the parasite occasionally adopts a chain formation which shows as a mycelium microscopically (Weidman, 1922). The flexural forms of seborrhoeic

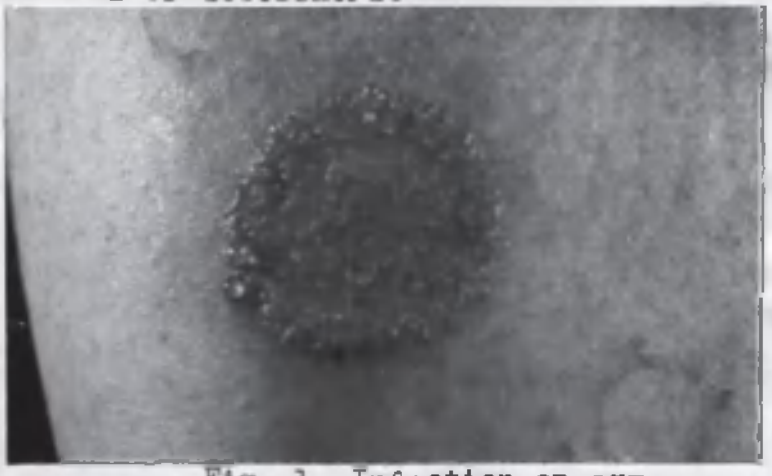

Fig. 1 Infection on arm.

Fig. 2 Patch on hand and neck.

dermatitis and psoriasis are usually accompanied by the more typical manifestations elsewhere. Erythrasma is a rare infection of the skin of the upper and inner aspect of the thighs with the fungus Microsporon minutissimum. It is a chronic disease causing little

itching, in marked contradistinction to tinea, and does not show the healing centre so typical of the common ringworms. The pathogen of erythrasma is extremely small, and requires the oil immersion objective of the microscope for its recognition. In passing, mention must be made of tinea versicolor, a condition of the chest and back where almost pure cultures of the fungus M. furfur grow in a condition of low grade parasitism.

Fig. 3 Patch of tinea, later stage.

Fig. 4 Tinea cruris.

In general, it may be said that any sharply defined patch of eczema should be viewed with suspicion until exonerated micro: :scopically.

Pedal Infections.

Pedal infection may take the form of maceration between the toes, or a typical patch on the instep or dorsum. Owing to retained moisture the outline is often lost, and the fungus burrows under the skin which peels off in large flakes (fig.5).

According to C.J. White (1927) there are ten clinical varieties of foot

Fig.5 Tinea pedis.

Fig.6 Infected nails.

infection, but they are too detailed for normal purposes, and the

three classifications of Williams (1922) should be used. They are: (1) Hyperkeratosis with scaling; (2) maceration of the skin between the toes; and (3) a vesicular form usually seen on the instep. Whitfield (1934) is of the opinion that all cases commence as a vesicular or bullous eruption, but Gray (1934) is not in entire agreement with him, and in this he follows White (1927) in postulating a primary intertriginous type.

Over the last few years all cases with an acute infection, seen personally, were vesicular in origin. The remains of a vesicular edge between the toes can sometimes be found with a hand lens even at an advanced stage, but it must be remembered that, in common with most skin diseases, a combination of types will be the most likely finding.

Fig. 7 Dysidrotic ide.

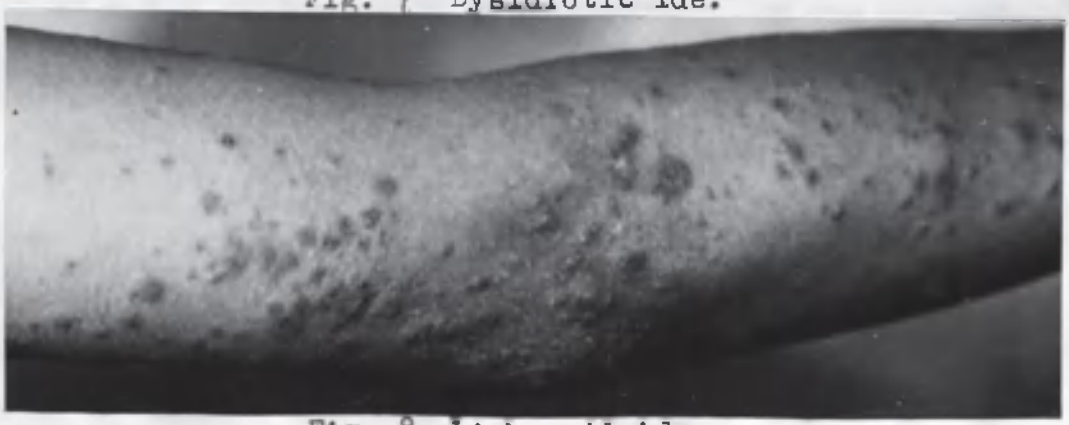

Fig. 8 Lichenoid ide.

Dysidrotic Eruptions.

The exact nature of the vesicular lesions, so frequently

seen on the hands and feet, has been rather obscured by the emphasis of the French school on the mycotic factor. Discussing vesiculo-bullous and squamous eruptions of the extremities, Darier (1919) stat: :ed that dysidrosis or pompholyx is not a distinct entity, but a syndrome; and, when not occupational or medicamental, is probably due to fungi. Later he stated (1928) that he found fungi in 80 per cent of cases of pompholyx. Ragab (1934) found fungi in 52 per cent of dysidrotic eruptions, but most of his cases were ordinary ringworm infections (McLachlan and Brown, 1934).

In a comprehensive survey of the mechanism of cheiropom: :pholyx, McLachlan and Brown (1934) found that many factors were responsible; and Wise and Wolf (1936) urged the need for caution in labelling dysidrotic conditions of the extremities mycotic.

True dysidrosis or blocking of the sweat pores is often seen on the lateral aspects of the fingers in hot humid countries, in the absence of mycotic foci elsewhere.

Nail Infections.

Nail infections are now regarded as much more common than formerly, and there is a growing weight of opinion that infected nails may show little or no clinical abnormality (Williams, 1928; Williams and Barthel, 1929; Gray, 1934; Wise and Wolf, 1936). Onychomycosis is usually secondary to infection elsewhere, and the infective agent gains entrance under the free margin of the nail. According to Kurotchkin and Chen (1931) there are two clinical varieties: (1) the commonest form, characterized by brittleness and

thickness of the nails with ridging and deformity (fig.6) and (2) a form in which the nails appear normal but lose their lustre. The diagnosis is made on the appearance of the lesions and the presence of ringworm elsewhere. Microscopical examination will, of course, be carried out as a routine.

Differentiation will have to be made from psoriasis, eczema, and syphilis. In psoriasis the nails may show minute pits or gross deformities, and the presence of typical lesions elsewhere will clinch the diagnosis. The other two diseases are rarely met with in Service patients.

Distal Eruptions.

In 1912 Jadassohn drew attention to spiny lichenoid papules which occurred in several cases of kerion under his care, and these distal eruptions are now fully recognized under the name of "ides", this being a short title for epidermophytide or trichophytide. They are due to the hæmatogenous spread of toxins, or more rarely fungi themselves, from a distal focus of infection, and are analogous to tuberculides. To produce an ide the skin of the subject must be sensitized, as the phenomenon is a manifestation of cutaneous allergy. Fungi are very rarely recovered from the ide.

It is generally insisted that the primary lesion be deep seated (Williams, 1927; Dowling, 1935), although distal eruptions have been observed in superficial infections (Peck, 1930; Ayres and Anderson, 1934). As the skin is sensitized to fungus products it should react to the intradermal injection of trichophytin.

The ide eruption may manifest itself in several ways, but the three commonest, according to Bloch (1921), simulate - (1) a

lichen eruption, (2) erythema nodosum, and (3) erythema scarlatini: :forme. By far the commonest type seen to-day is a vesicular lesion which is well illustrated in fig.7, and after that a small lichenoid eruption (fig.8) (Williams, 1921). It must be remembered, however, that the percentage of mycotic cases developing allergic eruptions is very small (Muende, 1930).

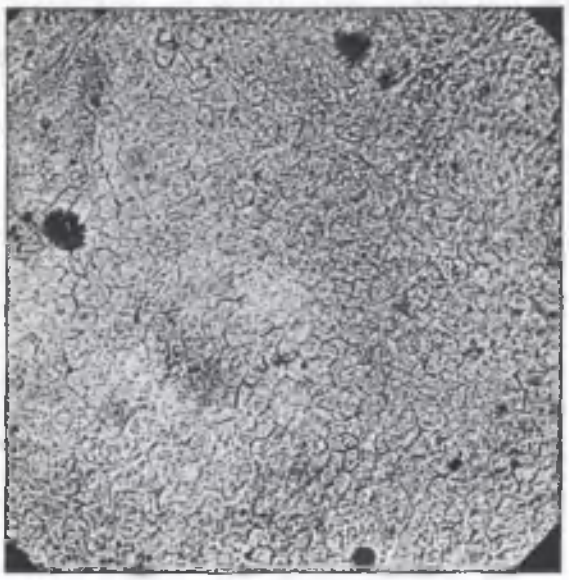

Fig.9 Intercellular spaces X 125.

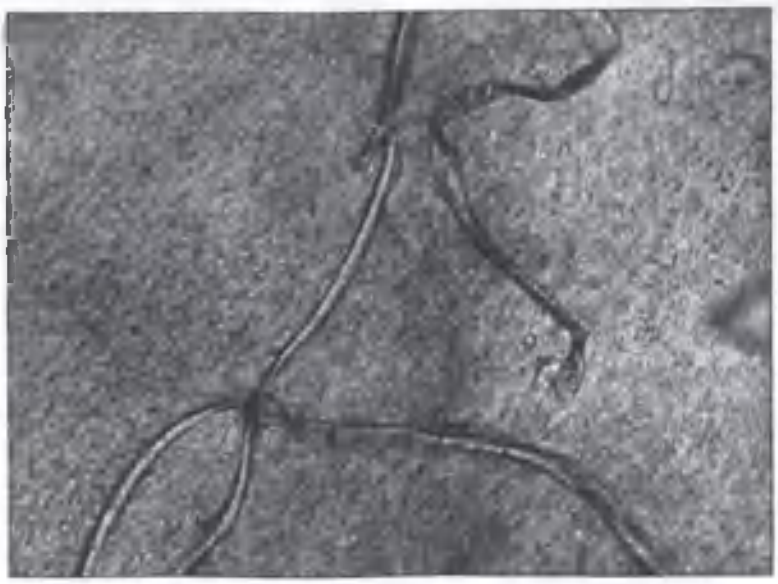

Fig.10 Contaminations

The Diagnosis of Superficial Ringworm Infections

Fig.11 Low power of fungus.

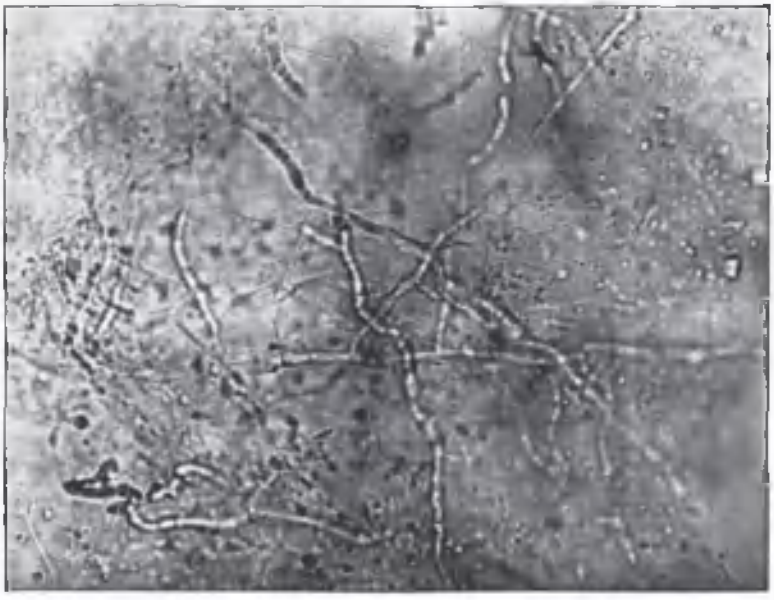

Fig.12 High power of fungus.

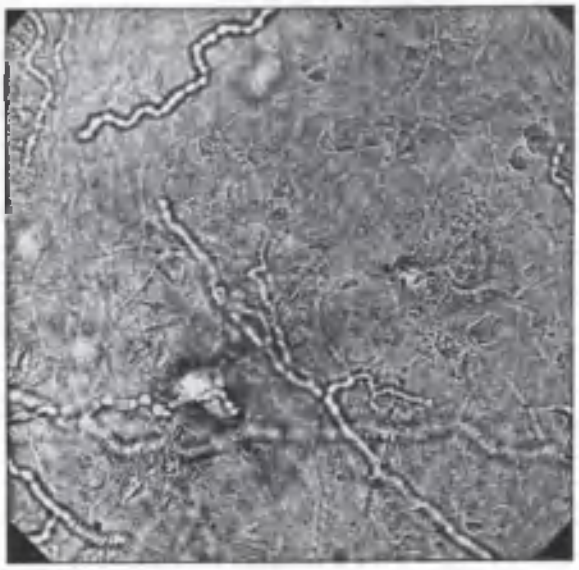

Fig.13 High power of fungus X 400

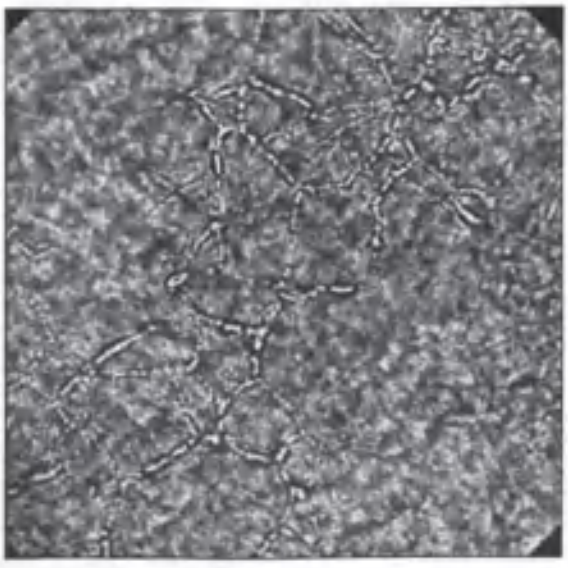

Fig.14 Mosaic X 400

Microscopical Diagnosis.

In microscopical investigations the two-thirds objective with a No.4 eyepiece is sufficient for a general search of the preparation, and the one-sixth objective for confirmation and details. Indirect light is best as it makes the hyphae stand out as refractile threads. A plane mirror can be used with the low power, when the material is not too thick, but otherwise concentrated light is essential. The scrapings should be taken from the active edge of the patch, and if very thin, as in tinea cruris, can be examined directly without mounting. Most specimens, however, will have to be cleared, and the agent most commonly used is liquor potassae. A few drops of the liquor should be added to the scales on a microscope slide, and the whole allowed to stand from one hour upwards without drying out. Gentle heating over a flame for a few seconds will assist the process. Thereafter, a coverslip should be applied and the preparation pressed out into a thin film.

Many methods have been devised to differentiate fungus in the film, but in practice the potash solution is the simplest. The scorch method of Bachman (1920) never seems to work, and the dyes advocated, such as cresyl violet, acidulated gentian violet and orange G (Bachman, 1920), require considerable delicacy of touch to prevent flooding the field. A combined clearing and staining agent is lactophenol cotton blue:-

Lactic acid	....	1 c.c.
Phenol crystals	....	1 grm.
Glycerine	....	2 c.c.
Aq.dest.	....	1 c.c.
Cotton blue	....	5 per cent.

and if the scales are thick they can be treated with hydroxide,

washed in water and mounted in L.C.B. (Swartz and Conat, 1936).

Fungi must never be confused with the intercellular spaces which frequently stand out as fine refractile lines (fig.9). On high power examination they will be seen to be continuous with the cell outline. Another cause of error is the presence of highly refractile vegetable and animal fibres derived from socks, and from swabs used to clean the area before scraping. They may assume all shapes and often have a ragged edge (fig.10).

The actual pathogen is a long seldom-branching refractile filament, and prolonged search of the field may be required to find it (Hopkins, 1937). The parasite crosses the epidermal cells and shows no tendency to follow their outline. Fig.11 shows the low power appearance of a mycelium, and fig.12 the high power appearance of the same preparation. The loss of refractility in some parts of the field is due to the focus of the camera. Fig.13 is a high power photograph from a different case.

Mosaics.

A strange "mosaic" (fig.14) of what at first appears to be a parasitic mycelium is sometimes seen, and doubt is freely expressed as to the nature of this organization. In England it is regarded as an artefact due to some interaction between the epidermal cells and the liquor potassæ used in mounting, and this view is gaining ground in America (Greenwood, 1935 Davison and Gregory, 1935; Swartz and Conat, 1936). Dowding and Orr (1936), however, still regard it as a disorganized fungus, and they have found the normal fungus forming part of a mosaic. In this connection the observations of Crawford-Jones (1935) on the fragility of fungi are of interest. In a personal investigation on tinea pedis

mentioned later, one case was seen where the mycelium ended in a mosaic; and the finding of this pattern in the film is now taken as an indication for a further search of the preparation, in some cases with success.

Nails.

In examining infected nails, shavings should be made with a razor blade, and they should include material from the under surface of the free edge down to the quick. Scrapings can be made with glass, but they are apt to lead to artefacts in the field, due to overlapping of the fragments with the formation of tenous refractile lines.

The specimen should be boiled for five minutes in liquor potassæ, and transferred to a slide with a platinum loop. It can then be spread by pressure on the coverslip.

Commentary.

As the fungus is frequently difficult to detect, the scrapings should be representative of all the active part of the lesion, and not one small area. In clinically positive cases with negative microscopical findings, Weidman (1927) advises dressing the part for a few days with 4 per cent dextrose to encourage the growth of fungi. I have used this method several times, but the results did not justify the measure.

Conclusion.

The fact that there is maceration between the toes does not justify a diagnosis of tinea pedis in the absence of microscop: :ical confirmation. Only in expert hands with years of clinical experience, backed by microscopical correlation, is this permissible. The casual observer need only be reminded that the apposition of

any two skin surfaces for a sufficient length of time will lead to maceration and dermatitis.

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CHAPTER FOUR

Trichophytin in Diagnosis.

Previous Investigations with Mycotic Extracts.

The use of mycotic extracts in the diagnosis of superficial tinea infers an altered state of reactivity in the body. That this state exists in certain bacterial diseases is a well-established fact, and for many years mycologists have endeavoured to find a cor: :ollary in ringworm infections.

The position with regard to deep ringworm has practically been cleared, but the occurrence of general changes in the super: :ficial type has caused much controversy. The tendency towards spontaneous cure in deep tinea (Sabouraud; Greenbaum, 1924) has been explained by the development of a general immunity, and the rarity of scalp infection in adults has been cited as an example of acquired herd immunity. Supporting the development of immunity Greenbaum (1924) and Scholz (1934) showed that by inoculating guinea-pigs cutaneously with ringworm they rendered the animals immune to further inoculation, and Sabouraud found that he could not use the same animal twice in testing for the pathogenicity of moulds. Greenbaum also showed that by inoculating the skin of a human with trichophyton gypseum spontaneous healing occurred in four weeks, and that the site of the lesion could not be reinfected as long as three months afterwards. Further, he claimed that the immunity thus produced was group-specific against the other ringworms, and said that "so sharply defined is this local immunity that reinoc: :ulation of a previously healed site only shows a take at the exact

edge of the previous lesion". Disproving this cutaneous immunization as applied to superficial infection, Weidman (1927) was able to infect the first interdigital cleft of his foot on two occasions with trichophyton cruris after a lapse of two years, although the interval appears to have been unduly long. It is also not uncommon in tropical practice to see more than one attack of tinea cruris in the same patient, despite the fact that Gray (1934) thinks this is rather unusual. McCrea (1931) reports repeated reinfections of the same areas on guinea-pigs with the common pathogens.

The occasional development of distal phytid eruptions in superficial infections has been established by Jadassohn and Peck (1929), Sulzberger and Kerr (1930), Peck (1930) and Ayres and Anderson (1934), while a fungus has been recovered from the circulat: :ing blood in some cases (Sulzberger, 1928; Peck, 1930; Strickler et al., 1932). It is of interest to note the inhibitory effect on ringworm cultures of serum from cases with phytid eruptions (Per and Braude, 1928; Ayres and Anderson, 1934). Ravaut and Rabeau (1932) even claim general changes in superficial yeast infections, and they have used an extract of yeast cultures, "levurin," as a diagnostic test.

From the foregoing evidence it is logical to conclude that superficial ringworm can sometimes cause local immunity, and there is reason to believe that the products of the causal fungus are not limited to the site of infection.

The diagnostic skin tests have given very variable results in the hands of different investigators. Such an eminent mycologist as Castellani (1934) places little reliance on them, although he publishes full details for the preparation of the extract; while Tarantelli (1926) and Garzella (1926) insist that to produce a

positive result the lesion should be deep-seated. Amberg (1910), using linear scarification, had thirteen positives from 131 casual patients; four of the thirteen had no previous history of ringworm. Repeating this investigation, Rosen, Peck, and Sobel (1931) intradermally tested 102 dermatological patients - seventy-two of them with some pedal skin lesion - and found a positive reaction in sixty-seven. There were nine proved cases of tinea pedis in this series, and eight of them reacted strongly. Muskatblit and Director (1933) encouragingly report 72 per cent. positive results in 300 cases of superficial tinea, while Ruete and Scholz (1934) claim 100 per cent. success in proved cases. In addition, the last-named observers contend that the extract used will only react against the fungus from which it is prepared, although this is disproved by Sulzberger and Kerr (1930). These group reactions are accepted generally, and are to be expected in view of the close biological relationship of the pathogenic moulds. Traub and Tolmach (1935) skin tested 135 cases diagnosed clinically as dermatophytosis with 83 cultural confirmations. 16 of the 83 cases were negative. Lomholt (1934) and Muende (1934) regard dermal tests as being of especial value in the differentiation of mycotic from dysidrotic eczema - a matter of importance in this country on account of the insignificance of the mycotic factor in the latter type of lesion (McLachlan and Brown, 1934).

The Present Investigation.

This investigation was carried out on 159 cases, 53 of them with superficial pedal tinea; the remaining 106 were casual patients used as controls. In every case a careful examination of the interdigital crural and axillary folds was made, and any skin surface showing maceration or desquamation was examined microscopic:

:ally for fungus, while the previous dermatological history was assessed as to the possibility of a fungus infection. Polyvalent trichophytin (Hoescht) was used throughout in a dilution of 1 in 50, and the diluent was employed as a control. Dilutions of 1 in 250 and 1 in 800 were also used at the beginning of the investigation, but were soon dispensed with as unnecessary. The solutions were renewed at monthly intervals to ensure against deterioration. After a trial of the linear scar and patch methods the intradermal route was chosen as being the most reliable, The trichophytin was injected with a fine needle into the flexor surface of the right arm and the control was injected in a similar site in the other arm, care being taken that the syringes and needles used were dry and free from traces of chemicals.

Four types of reaction were met with: (1) immediate and transient urticarial reaction; (2) inflammatory reaction; (3) inflammatory reaction with vesicle formation; (4) late eczematoid reaction. Types 1, 2, and 4 correspond to those described by Sulzberger and Wise (1932), and Type 3 has been added on account of its frequent occurrence in the strongly positive group. Type 1 was occasionally seen in the negative group, and, according to Bray, is due to tissue damage at the site of injection. A Type 1 reaction as described by Marcussen (1937) was met with once in this series. The patient was negative clinically, but gave a strongly suggestive history. Ten minutes after injection, the test site had swollen to the size of a duck's egg, while the control was negative. There were no accompanying general symptoms and the condition subsided completely in two hours, to be followed later by the usual type of reaction.

The results were read at intervals of one, two, four, and seven days, and were classified according to the following table:

Classification	Day of First Appearance	Maximum Diameter of Wheal	Vesicles	Desquam: :ation
Strong	1st-2nd	20-40 mm.	+	+ +
Medium	1st-3rd	10-20 mm.	-	+
Weak	2nd-3rd	10 mm.	-	-
Negative	-	-	-	-

The trichophytin when fresh appears to be remarkably resistant to heat, as ten positive and ten negative cases retested after autoclaving the extract gave the same results. This stability has been commented on by Goodman and Marks (1935).

A summary of the investigation is set out in tabular form below:

Type of Case	No. of Cases	Strong Reaction	Medium Reaction	Weak Reaction	Negative Reaction
(A) Microscopically proved tinea	53	28	9	9	7
(B) Control with pre: :vious history of tinea	38	8	10	12	8
(C) Control with negative history	68	2	15	14	37

Owing to the difference in the numbers of cases in the three groups it is proposed to scrutinize the table as it stands and not in terms of percentages. The seven negatives in Group A are disappointing, but four of those cases showed "mosaic" fungi microscopically. According to Weidman (1936) such "mosaics" are either a stage in the development of fungus or are due to some

fungoid action on the superficial layers of the dermis, while Whitfield (1935) regards them as artefacts due to interaction between the epidermal scales and the caustic potash used in preparation of the microscopical specimen. Repeated attempts to culture scales showing such "mosaics" were made under ideal conditions in Ramsbottom's mycological laboratory without success. Their exact nature, therefore, must be a matter for doubt, but it is of interest to note their frequent association with the accepted type of fungus. The results in Group B are gratifying, but the unavoidable personal error in assessing the history makes it difficult to draw a definite conclusion; and this becomes especially noticeable in Group C. Many patients may have had a patch of superficial tinea not diagnosed as such, or an interdigital type may have escaped notice completely. The frequency of such previous infections has been regarded as negativing the value of a positive reaction (Wise and Wolf, 1936), and this would seem to increase considerably the value of a negative reaction.

Conclusions.

From this small series and from observation of the skin tests in other hands, it is permissible to state that a strong reaction in a clinically suggestive case with a negative previous history lends a bias towards a diagnosis of tinea, while a negative reaction in a similar case precludes a positive diagnosis completely.

An interesting outcome of the investigation was provided by two negative reactors in Group C. Some time after testing they developed microscopically proved tinea pedis - one with an associated tinea cruris - and when retested three weeks and twelve months after infection gave a strongly positive result.

Summary.

The case for diagnostic dermal tests with fungus extracts is set forth and the results of some previous investigations are given.

An investigation is described and the results given in tabular form.

The limitations of a positive result are noted, and the value of a negative result in the differential diagnosis of pedal skin lesions is stressed.

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CHAPTER FIVE

The Incidence of Superficial Ringworm Infections.

In 1924 Butler and his co-workers examined 500 individuals in the U.S.Navy. This group embraced officers, marines, hospital patients, and medical orderlies, and although some of the percentage deductions do not stand statistical analysis, the general results are of considerable interest. 180 cases (36%) were found with a history of mycotic infection and 16 cases were discovered with active lesions on the hands or feet. Fungi were recovered microscopically in 11 of the 16 cases. Although not all of the 11 positive cases would give positive cultures, it is reasonable to assume that at least half that number harboured living pathogenic fungi. Wilson in 1932 examined the feet of 464 U.S.Army Reserve men and found only 3.45% unaffected. He did not confirm his diagnosis microscopically and many of his positive cases were undoubtedly interdigital maceration and not ringworm. A similar error is obvious in a lay statement in the U.S. Army and Navy Register (1938) which says that 95% of the Navy suffer from mycotic infections of the feet.

In a student investigation Hulsey and Jordan (1925) found 67 clinically positive cases in 100 individuals. They took scrapings from between the toes of 77 and found fungi microscopically in 49 of them. This high positive ratio was not borne out culturally, as they had only 5 growths from 49 cultures. However, this means that 5 students in the 100 examined were acting as potential reservoirs of infection. On a more ambitious scale, Legge et al.(1929) examined 3,100 fresh entrants to the University of California for the session

1928-1929. On entry 53.3% of the men and 15.3% of the women showed clinical manifestations between the toes. After the spring term, of 1,000 men and 997 women of this group who had been doing gymnastics, 78.6% of the former and 17.3% of the latter had interdigital lesions. The 25.3% increase in the case of the men was attributed to an old and unsanitary gymnasium. I should like to point out that here again the diagnosis was a clinical one. Another student investigation by Gilman (1933) at the University of Philadelphia showed an incidence of 60% tinea pedis among 785 students.

From a sociological aspect, Andrews and Birkman (1931) examined 520 male students in the second decade at a New York trade school and found that 65 (12.5%) showed clinical signs of pedal infection. The students came from a comparatively poor social class and the lack of hygiene in many cases was obvious, yet the incidence was much lower than in other group investigations. Another interest: :ing comparative study was made by Muskatblit (1933) on a group of 122 individuals, made up of 100 patients from the Bellvue Hospital Skin Clinic and 112 medical students. Clinically 85 of the patients and 103 students were positive, but as the investigator says "Although perfectly normal skin occurs rarely in the toe webs, it would be improper to consider toe-ringworm a 'universal' disease as many other causes besides fungi may cause similar changes." He goes on to say "the exact diagnosis of a mycotic process in the toe webs requires microscopical examination and cultures". Microscopical examination of this series showed 27 positives among the dispensary patients and 32 in the student group.

The relation of the incidence of superficial tinea to other skin diseases has shown a remarkable change within fairly

recent times. In 1929 Goodman classified the incidence of skin diseases reported from various sources during the years 1913 to 1927, and tinea was about eighth on the list. Later, in 1931, he reported (Goodman, 1931) that in his own practice at the New York Skin and Cancer Hospital, tinea had risen to second place during 1928 and 1929. In student health services it is regarded as the commonest disease of the skin (Gilman, 1934; Alderson and Reich, 1937).

Personal Investigations.

The following investigations were carried out on board H.M. ships of war and the cases are made up of officers and men of the Royal Navy, Royal Marines, and Merchant Navy. These individuals, for purposes of comparison with student investigations abroad, live under much the same conditions as the undergraduate body in any university. The common bathroom and washplace is an established institution and there is considerable congestion in changing and drying rooms. Apart from sprinters and distance runners, little attention is paid to foot hygiene, and bathers frequently walk on a soiled bath floor before drying. Under such conditions it would appear that a universal pedal infection is inevitable and the high figures from America would seem to uphold this conclusion. However, in H.M.S. Hood in 1934 with an average complement of 1.120 individuals, there were only 18 cases of mycotic infection. The cases during that year were diagnosed clinically. In the following year when an intensive study of ringworm lesions was instituted by myself, 25 cases of superficial tinea presented themselves for treatment from an enlarged average complement of 1,285. A trivial increase of 7 cases.

The following tables will facilitate scrutiny of the results:-

Table 1.
H.M.S. Hood. 1934.

Average complement	1120
Fresh cases	1496
Fresh cases of tines	18
No.of tinea cases hospitalised	1
Days sickness from tinea	5

Table 2
H.M.S. Hood, 1935.

Average complement	1285
Fresh cases	1627
Fresh cases of tinea	25
No.of tinea cases hospitalised	2
Days sickness from tinea	39

The cases of tinea had no relation to the number of total fresh cases presenting themselves from month to month, or to the time of the year as one would expect.

Table 3.

1934			1935		
Month	Fresh cases	Cases of tinea.	Month	Fresh cases	Cases of tinea.
Jan.	152	2	Jan.	107	0
Feb.	191	1	Feb.	107	0
Mar.	124	1	Mar.	168	2
April	40	1	April	29	2
May	94	2	May	145	3
June	169	2	June	129	1
July	93	2	July	134	4
Aug.	50	2	Aug.	72	0
Sept.	158	2	Sept.	189	6
Oct.	161	2	Oct.	192	4
Nov.	94	1	Nov.	198	1
Dec.	80	0	Dec.	157	2

Over the two year period there were 43 cases of superficial ringworm infection composed of the following varieties:-

Table 4.

Tinea pedis (interdigital type) ...	25	cases
" " (vesicular type).....	2	"
" manis	1	"
" cruris	12	"
" corporis	3	"

An associated tinea pedis and cruris so commonly described by many writers was not seen in this series.

The relation of tinea to other diseases of the skin is interesting, and it heads the list with eczema unplaced.

Table 5.

Tinea	43	cases
Scabies and pediculi	38	"
Impetigo	25	"
Other diseases of skin	122	"

It must be pointed out that H.M.S. Hood was in home waters during most of this time, and apart from a short stay in a sub-tropical country, the climate was temperate throughout. For compar:ison, I have compiled some figures from the records of H.M.S. Dorsetshire for the twelve months April 1935-April 1936 on the China station.

Table 6.
H.M.S. Dorsetshire.

Average complement	665
Total fresh cases	2561
Fresh cases of tinea	44
Days sickness due to tinea	122

It will be seen that during 1935 the cases of tinea for the Dorsetshire are almost double those for the Hood which had practically twice the complement, while the days sickness is much greater, due doubtless to the heat and humidity of the China station. It is a fact that all skin infections are notoriously difficult to treat in tropical countries.

So far these figures have dealt with overt infections applying for treatment, and in 1935 it was decided to examine a representative cross section of the personnel to determine the number of latent cases. This was done at Gibraltar and in China during the years 1935-1937. The men were drawn at random from the various branches in the Navy and were not complaining of skin disease. A case was regarded as clinically positive only if there was present a definite vesicular lesion on the foot. Incidentally, these figures

apply to foot cases only, as no lesions were discovered elsewhere in the series.

Table 7.

No. examined	Clinically positive	Micro-positive
428	71 (16.6%)	33 (7.7%)

In the 71 clinically positive cases there were 34 in the 4th decade; 32 in the 3rd decade; and 5 in the 2nd decade. 209 individuals were of the engineer branch and they had only 29 positives with 12 microscopical confirmations. As a branch, they work under conditions of heat and moisture with frequent washing in crowded bath spaces, all of which would seem ideal for fungus propagation, yet their positive rate was lower than any other branch in the investigation. The more frequent bathing required by the engineers may offset the conditions in which they work.

Another foot survey on a more extensive scale was carried out during the autumn and winter of 1938 in small ships attached to the Home station. A careful history was taken from each individual with regard to the possibility of a previous mycotic infection and any case with maceration or desquamation between the toes, no matter how slight, was regarded as 'abnormal'. Clinical examination was made in the morning and the scales were examined microscopically in the afternoon after soaking in 10% liquor potassae for at least two hours. In order to lessen the chances of missing fungus in scales, the first 150 scrapings were re-examined after 24 hours, but in no case did a previously negative slide become positive. The pathogen was never recovered in the macerated type of lesion but was frequently found in feet showing only a tiny area of hyperkeratosis in the fourth interspace. In other words, unless the interdigital skin is

absolutely intact there is always the possibility of a ringworm infection. I am inclined to think that the finding of pathogenic moulds in clinically negative feet is due to overlooking such a hyperkeratotic lesion.

The following results were obtained from this investigation:

Table 8.

Number of individuals examined	622
Individuals with pedal lesions.....	319(51.3%)
Microscopically positive	33(5.3%)
Individuals with previous mycotic history....	188(30.2%)
Cases of previous history with abnormality...	134

Of the 319 abnormal cases, only 23 showed no lesion in the 4th interspace. Apart from eczematoid areas on the dorsum, this was due to a malformation of the foot causing cramping of the middle toes with an unduly open 4th interspace. 72.7% of the 'abnormal' cases (319) showed a closed or cramped type of foot and a similar condition was present in only 34.7% of the normal cases (303). I regard this as strong proof that apposition of the skin surfaces is one of the main factors in producing interdigital lesions. There were 141 'abnormal' cases in the 4th decade; 153 in the 3rd decade; and 21 in the 2nd decade, and this agrees with White's findings in his private cases (Table 2, chap.1). The group in the 5th decade was too small to be of any statistical use.

Once again the engineers vindicated their profession as they had an abnormality rate of 52.4% from a total of 273, while the executive branch showed a rate of 54.2% from a total of 251. From these investigations, one is forced to the conclusion that immediate working surroundings, in the case of the engineers, has little influence on the incidence of pedal infections and it may be that the common denominator is the bathroom.

Cultural Investigations.

In collaboration with Miss F.L. Stephens of the British Museum of Natural History, it was decided to investigate the mycotic flora of the positive cases in the last investigation. Accordingly sixteen of the most heavily infected were selected and the scales sent for culture. Before despatch they were defatted with ether and sealed in sterile black photographic paper envelopes.

In all cases plants were made on Sabouraud's medium and ordinary agar media adjusted to a neutral pH. Incubation was at room temperature and 37 Deg.C. In practically every case repeated sub-cultures had to be made on account of saprophytic overgrowths, despite the fact that in the laboratory every batch of scales was treated with some antiseptic. The classification was according to Dodge's Medical Mycology (1936) with some personal modifications to comply with recent mycological opinion. On the kind advice of Sir Aldo Castellani trichophyton purpureum was renamed trichophyton rubrum.

The following pathogens were recovered:-

Table 9.

	Pathogenic moulds	Bacteria	Yeast
Case 1	Trichophyton rubrum	Staphylococci	Nil.
" 2	Trichophyton rubrum	"	"
" 3	Trichophyton interdigitale	"	Unidentified
" 4	Corethropsis hominis (Vuill)	"	"
" 5	Nil.	"	Nil.
" 6	Nil.	"	"
" 7	Trichophyton rubrum	"	"
" 8	Epidermophyton floccosum and Aspergillus.	"	Unidentified
" 9	Trichophyton interdigitale	"	"

Table 9 (Contd.)

	Pathogenic moulds	Bacteria	Yeast
Case 10	Epidermophyton floccosum and Trichophyton gypseum	Nil.	Nil.
" 11	Epidermophyton floccosum	Staphylococci	Unidentified
" 12	Trichophyton rubrum	"	Nil.
" 13	Trichophyton rubrum	"	"
" 14	Trichophyton rubrum	"	"
" 15	Trichophyton rubrum	"	"
" 16	Trichophyton rubrum	"	"

Case 4 presented a most unusual parasite, although Brumpt (1936) quotes Gluigani as recovering it from an interdigital lesion. Case 8 presented what was at first thought to be an achorion. Special attention was directed towards this fungus but a pure culture finally proved to be an epidermophyton. In an interesting paper, Lewis, Rosenfeld, and Hopper (1937), collected the reported cases of achorion infection of the glaubrous skin.

Incidence of Nail Infections.

Considerable difference of opinion exists as to the frequency of ringworm infection of the nails, and a comprehensive survey of the literature on the subject was published by Kittredge in 1933. My own results have been consistently negative, but this may have been due to an unfortunate choice of material. In examining suspect nails it is essential to take shavings from every part of the nail, clinically negative as well as positive, as the pathogen may be localised in one small area.

Summary.

Reports on superficial ringworm infections, chiefly from abroad, have been examined, and the errors in diagnosis pointed out.

The results of some personal investigations have been given.

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CHAPTER SIX

The Viability of the Common Pathogenic Fungi.

A knowledge of the viability of the causative fungi in the infected area; in detached scales, and also in relation to such factors as heat and cold; moisture and pH; X- and ultra-violet rays and chemical agents is essential, in order subsequently to exhibit logical prophylactic and therapeutic measures. Such a study would seem to place the treatment of superficial mycotic infections on a scientific and satisfactory basis, and yet, according to most mycologists, the results are disappointing (Whitfield, 1934), while doubt has been expressed if tinea pedis is ever cured (Sulzberger, 1937). Many factors have been blamed for this; chiefly survival of the mould in spore form in the infected area and reinfection from diseased nails (Semon, 1922; Williams, 1928; Beintema, 1931). Doubtless in many cases the infective agent is difficult to eradicate, but lesions of the skin surface due to mechanical causes may persist long after the specific factor has been dealt with.

Viability in the Infected Area.

Treatment of a mycotic lesion will cause an early disappearance of mycelia. The development of immunity may also contribute, although this is a somewhat controversial point. It is difficult to account for the survival of spores in the lesion, as Schramek (1916) and Strickler and McKeever (1934) have shown that fungi burrow superficially, and they have recovered fungal elements several inches from the lesion in some cases. Most forms of treatment however, aim at some form of penetration and decortication, and the

medicament invariably comes in contact with an area well beyond the lesion.

It is interesting to note that pathogenic moulds do not usually occur as saprophytes on healthy skin. In a series of cultures from the interspaces of the feet of 100 clinically negative patients Burgess (1925), had no positive results, and Muskatblit (1933) could not find fungi microscopically or culturally in the clinically healthy feet of 212 casual subjects. On the other hand, Cornbleet (1926) obtained three pathogens from the interspaces as the result of cultures from 100 carefully selected cases with a negative previous history. On the lines of Cornbleet's investigation Kurotchkin and Chen (1930), recovered five pathogens from 150 normal cases, and Downing and his collaborators (1937) had two positive results in a series of 300 cultures of scrapings from the skin of 100 clinically negative cases.

These results rather tend to show that the positives were carriers without showing signs of infection, but they may have been accidently contaminated from infected cases, and the high incidence of the disease in America and China lends support to this view. Pathogenic moulds do not normally occur as saprophytes under natural conditions, although Muende and Webb (1937) have recently reported a case with Trichophyton Gypseum-asteroides. As the result of personal examination microscopically - with cultural confirmation in suspicious cases - of scrapings from between the toes of over 500 clinically negative cases, only one case was found harbouring fungi - Epidermophyton inguinale - and he gave a history of dermatitis of the feet some years previous to examination.

Viability in Detached Scales.

The widest variations of opinion exist as to the maximum time fungi in infected scales can remain viable outside the body. Dixon (1924) reported a case of tinea pedis where he recovered the organism from the shoes months after the patient had ceased to wear them, and Jamieson and McCrea (1937) obtained 16 pathogens from the footwear of 52 positive cases, in some instances months after the shoes had been discarded. In cultural investigations, Bruhns, Alexander and Kadisch (1929) recovered fungi months after spreading them on leather, and Bonar and Dreyer (1932) found that Trichophyton interdigitale grew well on a variety of natural media and resisted drying for a considerable time. Farley (1921) kept infected scales in paper envelopes and cultured them at intervals with the following results:-

Type of case.	No. of cases.	No. giving positive results.	Remarks.
Tinea cruris	9	3	E. inguinale viable after 145, 174 and 433 days.
Tinea unguium	2	1	Unindentified fungus viable after 418 days

while in a similar investigation quoting Mitchell (1922), Weidman's results (1927) were as follows:-

Infection.	Organism.	Observers.	Cases.	Cultures secured.	No. of days viable.
Toe ringworm	Tr. interdigitale	Weidman	1	1	180
Toe ringworm	Tr. interdigitale	Weidman	1	0	
Toe ringworm	E. cruris	Mitchell	2		180-300
Toe ringworm	Tr. interdigitale	Mitchell	1	1	300

Drying of the scales before storage is necessary to prevent overgrowth.

The above investigations place the maximum period of survival of fungi in scales at over a year. Previous to these

reports, Dold (1920) kept infected scales in sterile envelopes, and found that there was no growth on culture after thirty days. It is worth stressing that the pathogenicity of the secondary growths was not investigated, and the following personal cases would tend to indicate that this undergoes modification outside the body.

(1) A young man reported with an area of weeping eczema in the fourth interspace, extending to the dorsum of the right foot. The condition had been present for an indefinite time and the acute stage had lasted two weeks. On examination, the skin between the affected toeswas red and macerated, and in some places there was crust formation. Small vesicles were present at the periphery of the lesion. Scrapings from the centre and from the crusts were negative, but the vesicles and marginal scales showed abundant fungal mycelia microscopically. Scales and vesicles were removed, and after treatment with ether, were despatched for culture. A heavy growth of E. inguinale resulted. Examination of the patient's 21 Messmates, who shared the same bathroom, showed 12 cases of interdigital maceration, such as is common in young athletic men in hot weather (Keller, 1926); the remainder were negative. All the macerated cases were scraped and examined microscopically with a negative result. They were examined fortnightly on two occasions, but no fresh cases appeared and none developed subsequently. The contacts took no precautions and the bathroom floor was not sterilized in any way.

(2) An officer presented himself with an extensive tinea cruris of three weeks' duration. There had been no lesion before that time and the feet were clear. Mycelia were seen in abundance

microscopically, and a heavy growth resulted on culture. He was in the habit of using a group of three lavatories, used on an average by 30 officers, and yet no fresh cases resulted. Infected scales must have been picked up by others, as they were easily recovered, and proved microscopically, from the crural seam of the patient's underclothes.

(3) A sailor reported with a vesicular eczema over the dorsal aspect of the left foot extending between the interdigital spaces. The condition had been present three weeks; two weeks in a mild form, and a week in a weeping eczematized form. He had been examined a short time before in the routine clinical and microscopical examination for interdigital infection and pronounced negative. Abundant fungi were recovered microscopically from the lesion, which showed practically no secondary infection. The patient had been using a tiled wash-place shared by 38 others, and clinical and microscopic examinations of scrapings from between the toes of these men were negative. Examination of the inside of the left sock produced a few scales which showed mycelia. The bathroom floor was scrubbed with soap and water and no antiseptic was used. No fresh cases appeared.

In view of the alleged viability of the pathogenic fungi and the ideal conditions for implantation of infection, warmth, maceration, and moisture, it seems strange that no fresh cases resulted. In addition, all three occurred in a subtropical summer.

Mercer and Farber (1935) investigated an epidemic of tinea cruris due to E. inguinale on a liner, and came to the conclusion that cross infection was taking place chiefly by towels and articles

of clothing, while Gjessing and Mossige (1937) reported a familial outbreak where the infection was due to the use of common towels. The old theory, that infection of the feet is due chiefly to contact with swimming-bath floors, etc., is rather losing favour, and Sulzberger (1937), states, that at least in cases of reinfection, the local skin resistance is of paramount importance. Some time ago an investigation on the mycotic flora of floors was carried out in the department of dermatology of the National Medical College of Shanghai. Many of the patients in this department are of the coolie class and do not wear shoes, yet the results were completely negative (Reiss, 1938).

Heat and Cold.

It is well known that pedal infections reach their peak of incidence in the hot summer months, but this is probably due to the associated factors: increased sweating, maceration of the skin, and more frequent exposure, rather than to the actual increase in the surrounding temperature. Recently it has been suggested that certain types of rubber footwear predisposed to infection, but this can be explained by the delayed evaporation and subsequent maceration of the skin which is bound to take place when the feet are hermetically sealed. The maximum lethal temperature for pathogenic fungi in culture has been determined by Weidman (1927) at between 48 and 51°C., and this has been confirmed by Tate (1929), although C.J. White (1927) believes that fungi are not destroyed by boiling, and Mitchell (1922) claimed to have recovered E. inguinale by culture after boiling in 15 per cent. potassium hydroxide. Few pathogens, however, survive a high temperature, and in view of the constant results obtained by Weidman, the lethal temperature may be regarded

as fairly constant. How far this holds good in vivo is difficult to say, but treatment along thermal lines would not be difficult with induced currents.

The effect of cold on cultures has not received much attention, although Taylor (1930) advocates spraying the affected part with ethyl chloride as a curative measure. Similarly Freeman (1925) advised stroking the area with carbon dioxide snow. The resulting extensive desquamation which follows such treatment may be the main factor in resolution. From a bacterial analogy the more resistant moulds would be likely to survive a certain degree of cold in spore form, and this may be the explanation of the remissions, in the course of mycotic infections, so frequently seen in cold weather.

Moisture and pH.

Moisture is essential for the growth of moulds, but under certain conditions they are able to survive drying out in culture on account of spore formation (Dixon, 1924; Bruhns et al., 1929; Bonar and Dreyer, 1932). Moisture is also the main factor in producing maceration of the skin, and this can be demonstrated by omitting to dry the interdigital spaces after bathing for a week. The resulting condition, however, is merely one of interdigital maceration, and a superadded infection with a pathogenic fungus is essential to complete the picture of tinea pedis. Souter (1937) regards the high incidence of infection in the leisured classes as due to carelessness after bathing, with subsequent preparation of the soil for infection. As the result of their investigations, Norton and Novy (1934) showed that the degree of moisture present has a direct effect on the bacterial flora of the skin, and Cornbleet (1932) demonstrated that the self-sterilizing power of the natural folds of

the body is lower than that of the surrounding skin. Personal attempts to inoculate dry scarified human skin with proved pathogenic fungi have been invariably unsuccessful. Indeed it is difficult to reproduce ringworm infections experimentally under any conditions.

The high incidence of infection in the fourth interspace has led many investigators to seek an altered sweat reaction in this location. In the accepted absence of alkaline apocrine glands Gray (1927), and Levin and Silvers (1932) attribute the high pH of the sweat in the interspace to decomposition in the warm tunnel formed by the fourth and fifth toes. Moreover, the latter investigators showed that the surface reaction of the skin becomes alkaline when evaporation is prevented. Some time ago, on the assumption that men with large feet would be more likely to squeeze into tight-fitting shoes with constant apposition of the two outside toes, the author attempted to correlate the incidence of maceration in the fourth interspace with the size of shoe worn. The results, however, were inconclusive. In an ingenious investigation as to the pH of the area in question, Weidman (1927) attempted to identify morphological remnants of a secondary sex gland found in certain ruminants by serial section of a number of human feet. He was unable to find evidence of special glands in the region. Working on the fermentative properties of the moulds, Tate (1929), postulated that the pathogenic fungi contain an enzyme which is active only in an alkaline medium.

X- and Untra-Violet Rays.

A sufficiently long exposure to X-rays will undoubtedly kill fungi in culture, but a fungicidal dose to the skin will result in permanent damage in the form of atrophy of the superficial glands, scar formation, and telangiectasis. Thus X-rays are never

used to destroy fungi in the skin (Gray, 1935), although small doses may be useful in resolving the eczematoid condition after destruction of the pathogen. Glasson (1920) used X-rays as an adjuvant to chrysarobin and reported good results, and Ingram (1935) states that fractional exposures may be useful in clearing up a chronic resistant case. It is obvious that a heavier exposure can be given to an area naturally keratotic and devoid of superficial glands. The use of X-rays in an acute case may even have a slightly stimulating effect on the causative mould (Chavarria and Clark, 1924). In this country X-rays are comparatively rarely used, and Butler, Houghton, and Cooper (1924) consider their employment in superficial infections unnecessary. Their use is frequently followed by distal "ide" eruptions (Williams, 1927).

The supersoft or long wave-length Grenz rays have been employed on account of their lack of penetration (Muskatblit and Ouspensky, 1933), and reports indicate that they do little damage to the skin (Bucky, 1927; Dorne and White, 1931). They cannot, however, be regarded as fungicidal, and Buschke (1931) reports four microsporon infections of the scalp treated unsuccessfully without epilation. Similarly Dorne and White (1931) found that the common pathogenic fungi were little affected, although yeast lesions responded fairly well. On the other hand, Scholtz (1932) reports five cases of dermatophytosis, resistant to ointments and X-rays, which cleared up with Grenz rays.

A word of warning: X-rays can cause great damage, and they should be used only by the expert.

Exposure of bacteria to ultra-violet light has a rapidly lethal effect, and the method has been applied commercially to

drinking and bathing water plants. Fungi are more resistant (Gomez-Vega, 1936), and Scott and McKinley (1930) estimated that an exposure of from five to twenty-five minutes at a distance of one foot is necessary for destruction. In an interesting investigation, Chavarria and Clark (1924) found that fungi could be sensitized to visible light by eosin, and this has been confirmed by Gomez-Vega (1936). The latter investigator found that mercurochrome was particularly effective when used in this way.

Chemical Agents.

The fungicidal agents in common use in this country are iodine and salicylic acid, and the former is generally accepted as being one of the most powerful, even in high dilutions. Strangely enough, salicylic acid has been found to be a poor fungicide in vitro. Schamberg, Brown and Harkins (1931) found that iodine kills *E. interdigitale in culture in a dilution of 1:85,000 after an* exposure of fifteen minutes, and it retains its properties in the presence of blood and vesicle serum (Kingery, Williams & Woodward 1935) As the result of in vitro experiments Gould and Carter (1930), state that the addition of benzoic to salicylic acid raises the fungicidal power of the latter, and Strickler (1933) has suggested the potentiation of iodine by the addition of potassium iodide.

Smyth and Smyth Jnr. (1932) recommend, 100 per cent. pine oils and state that on account of the low vapour pressure of the oil, contact with the skin is maintained for a considerable time. Aqueous and alcoholic solutions of essential oils have been credited with strong fungicidal powers, and their use has been favourably reported on by Myers and Thienes (1925), Mitchell (1927, and Kingery and Adkisson (1928). Legge, Bonar and Templeton (1934) advise the

addition of thymol 1·4 per cent., to Whitfield's ointment, and say that the therapeutic successes jump from 47·9 per cent. to 64·4 per cent. Various dyes have been found to have high lethal properties and mercury acetate crystal violet in 25 per cent. solution with alcohol and acetone and mercury acetate fuchsin have been recommended (Schamberg et al., 1931). It is interesting to note that acid fuchsin stimulates growth in culture (Gomez-Vega, 1936), although basic fuchsin is a definite fungicide.

The following table (Schamberg and Kolmer, 1922) shows the fungistatic activity of various therapeutic agents:-

Medicament	Highest fungistatic dilutions for T. rosaceum
Iodine	1:100,000
Brilliant green	1:16,000
Mercuric chloride	1:4,000
B naphthol	1:3,200
Phenol	1:1,600
Crystal violet	1:500
Iodoform	1:400
Ammoniated mercury	1:200
Resorcin	1:200
Methylene blue	1:200
Gentian violet	1:200
Fuchsin	1:200
Salicylic acid	1:50
Benzoic acid	1:40
Sodium thiosulphate	Not in 1:20
Chrysarobin	Not in 1:10

This table, from the same source, shows the fungicidal activity of some of the medicaments in common use:-

Fungicidal Activity for T. rosaceum.

Medicament	Exposure			
	15 mins.	1 hr.	3 hrs.	24 hrs.
Brilliant green	1:25	1:80	1:200	1:200
Crystal violet	1:25	1:50	1:50	1:200
Gentian violet	Not in 1:25	1:25	1:50	1:50
Iodine	1:5,000	1:5,000	1:7,500	1:10,000
Phenol	1:25	1:25	1:50	1:150
Mercuric chloride	1:10,000	1:10,000	1:10,000	1:15,000
B naphthol ...	1:25	1:25	1:50	1:100

It will be noticed that "fungicidal" is used to denote destruction of the fungus, and "fungistasis" to denote inhibition of growth. Chlorine has been recommended by some workers as cheap and effective (Osborne and Hitchcock, 1931; Osborne, Putman and Rickloff, 1933; Shaffer and Carey, 1933; Emmons, 1933), and Spring (1933) found that fungus in scales could be killed by immersion in chlorinated swimming water for two hours. Formaldehyde has been used (Ayres Jnr., Anderson and Youngblood, 1931; Y. Henderson, 1932), and it has been found effective in destroying fungus in footwear. Sodium thiosulphate has been recommended (Gould, 1931) as a fungicide in bathing establishments, but its action has been unfavourably reported on (Osborne and Hitchcock, 1931; Kingery et al., 1935), and it loses its fungicidal properties on contact with chlorinated swimming water.

Three commercial fungicides have been used therapeutically: abracide, mycocten, and paranitrophenol. Abracide is the proprietary name for a mixture of two hydroxy-methyl-butyl benzines, and it is used to prevent the growth of moulds in paints and enamels. It is extremely popular in the army, and has been credited with a high therapeutic efficiency (Crawford-Jones, 1935). Mycocten is an ester

of oxy-benzoic acid, and it is used to prevent the growth of moulds in foodstuffs. Success has followed its clinical application in solution and ointment form (Noel-Goldsmith, 1936). Paranitrophenol is used in the leather trade to sterilize untreated hides (Robertson, 1935), and good results have followed its therapeutic use (Semon, 1934; Marriot, 1935). It has been used by myself for some years, and there have been no cases of failure so far. Even wood preservatives have been pressed into service, and Wieder (1935) has reported favourably on the fungistatic power in vitro, of two phenols used to preserve wooden posts.

Commentary.

While it is admitted that pathogenic fungi can remain viable for long periods in effected scales, there is no proof that they can retain their pathogenicity for a similar period. This factor, combined with the sensitivity of the parasite to most of the common fungicides, make it difficult to account for the high proportion of therapeutic failures in foot cases. The theory that the parasite is not difficult to kill but to get at, is hard to explain in view of the superficial habitat of the infective agent and the fact that most treatments have a penetrative effect.

To a student of therapeutics, it is obvious that too much attention has been paid to the "seed" and not enough to the "soil". In the treatment of tinea pedis it is not enough to eradicate the fungus in that lesion; attention must be paid to local hygiene, and measures to ensure ventilation of the feet and make the location unsuitable for fungi must be instituted.

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CHAPTER SEVEN

Treatment and Prophylaxis.

At some time or other since the discovery of mycotic skin lesions, practically every antiseptic has been lauded as a specific cure. This at first glance tends to demonstrate the inefficacy of all, on the other hand, it may also show that any logical treatment in careful and experienced hands will be successful. Too many practitioners regard the common pathogenic fungo as indestructible, a state of affairs which is not borne out in the laboratory, and this despairing attitude is evident in the casualness of their treatment. It is also not uncommon to find illogical combinations of treatment in the same patient. This is bad policy, and is undoubtedly one of the best methods of producing dermatitis venenata. As in all branches of medicine, it is much better to adhere to a few proved remedies than to rush blindly from one new discovery to another.

Superficial ringworm infections can be permanently cured, provided the disease is regarded as a whole and not as a localised skin infection. It is not enough to eradicate the parasite in the infected area; infected clothes must also be dealt with, and if possible, the source of infection traced. The difficulties in the latter method of approach were pointed out by Weidman (1934) when he said -

"The hygiene of the problem is so complicated that I doubt whether the difficulty can be met by that route. It is impossible to sterilise all the wearing apparel of the patient; even so, there would still remain the floor coverings in our homes, hotels, shower

baths, etc. It seems to me that the real approach to the millenium in the way of treatment is to establish conditions in the inter: :triginous locations in which the fungi work and mobilise, which will make these locations undesirable to the fungus."

In some cases it will be impossible to sterilise all the clothes, but it is essential to eradicate the fungus in garments in direct contact with the infected area. In the case of pedal infections, it will be necessary, subsequent to treatment, to acidify the interdigital spaces as a prophylactic against reinfection.

Common Therapeutic Agents.

Iodine.

Of the various medicaments in common use iodine holds pride of place, and its efficacy has been proved in vivo and in vitro. It is especially useful in tinea cruris and can be applied as the strong or weak tincture or potentiated with potassium iodide as suggested by Strickler (1933). The French use intravenous solutions of iodine, and they recommend them in this way for tinea barbae and other deep seated infections (Roxburgh, 1937).

Iodine crystals		2
Potas. iodide		3
Aq. destil	ad	100

Commence with 1cc. in 5cc. distilled water and increase by 1cc daily until 5cc. are injected in 15cc. distilled water. Swartz (1935) reports good results from ethyl iodide inhalations.

There is usually some irritation when iodine is applied to the crural region, and if this is not carefully watched an irritant dermatitis may be set up. I have a personal aversion to iodine in any form, and I have seen a great many bad results from over treatment.

Salicylic acid.

This acid is universally used in mycotic infections, and it

is usually combined with benzoic acid as in Whitfield's ointment -

Ac.salicyl.	grs.15
Ac.benzoic.	grs.25
Paraf.mol.	drs. 2
Ol.cocois.nucis. ad	oz. 1

The ointment is extremely fluid in hot weather and grs.15 of hard paraffin can be added as a stiffening agent. It is somewhat irritat: :ing when used near the scrotum, and Whitfield (1934) recommends that it should be used for five days at a time with rest periods of three days. It has the advantage of being colourless. If a paint is preferred the following is useful:-

Ac.salicyl.	dr.1
Ac.benzoic.	oz.1,1/2
Acetone	oz.1
Sp.vini meth. ad	oz.4

The above combinations of salicylic acid sometimes yield disappointing results, and Whitfield says that some of the claims as to their usefulness are extravagant. I always add 1.4% thymol to Whitfield's ointment as suggested by Legge et al.(1934). This of course precludes its use round the anus. Parke, Davis & Co. market a salicylic ointment and paint under the name of 'Mycozol'. An iodide salicylic acid paint has been advocated by Strickler -

Iodine crystals	1.3
Potas.iodide	1.9
Ac.salicyl	1.9
Ac.boric	3.8
Alcohol 50% ad	59.1

and the originator claims a very low percentage of irritant reactions.

The use of macerating ointments in interdigital pedal infections necessitates frequent curettage, and this should always be done personally. Such a procedure removes dead skin and thoroughly exposes the infected area. It is also desirable, no matter what routine is ad-pted, to supervise every step in the treatment personal: :ly. The results from such personal treatment are much more

satisfactory.

In the somewhat rare mycotic pruritis ani, Castellani (1924) recommends a combined salicylic ointment as originated by Deek -

Ac.salicyl.	4	parts
Bismuth subnit.	10	"
Mercury salicyl.	4	"
Ol.eucalypti.	10	"
Paraf.liq.		
Adeps lani	aa 100	

From a single personal experience I can best describe this preparation as 'very stimulating'.

Chrysarobin.

In the course of years chrysarobin has been found to be almost a specific in the treatment of superficial mycotic infections. Indeed it was for the treatment of these conditions that it was first introduced (Norman Walker, 1932). Exhibited as an ointment -

Chrysarobin	grs.20
Adeps lani	
Paraf.mul.	aa drs.4

it is specific for tinea cruris. Inunction should be carried out once a day for four to seven days, according to the reaction of the patient. Some will complain of slight burning from this treatment, but it is surprising how few side effects are produced. It should be followed by a soothing lotion, such as lotio calaminae, to which half a drachm of liquor picis carbonis or 3% ichthyol can be added.

A synthetic derivative of chrysarobin - cignolin, prepared by Bayer, is extremely useful in tinea pedis. In ointment form -

Cignolin	grs.10.
Adeps lani	
Paraf mol.	aa.drs. 4

it should be rubbed in to the infected area once daily, taking care

that the interdigital spaces are also treated. This treatment can be exhibited to cases of vesicular tinea, and I have even applied it to the weeping eczematoid type with success. Seven to fourteen days of daily applications will effect a cure. After inunction the parts should be wrapped in gauze, and the patient should wear loose fitting shoes or sandals. It may even be necessary to put him to bed in the later stages of the treatment. Cignolin can be applied to the crural type of tinea, but there is usually considerable discomfort from this measure.

When using chrysarobin and its derivatives, the irritant effect on the eyes should be remembered, in addition to their ability to "turn fine linen into purple raiment".

Burgess (1938) recommends a chrysarobin ointment with salicylic acid (Dreuw's ointment) -

Ac.salicyl.	6
Chrysarobin	12
Ol.rusci	12
Lin sap.mol.	15
Paraf.mol.	60

Chrysarobin and cignolin do not act well in paint form.

Dyes.

Fuchsin is undoubtedly one of the best anti-mycotic dyes and it is most commonly employed in the paint form originated by Castellani (1929).

Sat.alcoholic soln.basic-fuchsin	10cc.
5% aq.carbolic acid soln.	100cc.
Filter and add	
Boric acid	1grm.
After two hours add	
Acetone	5cc.
Two hours later add	
Resorcin	10grms.

Store in a dark coloured bottle.

It is a non-irritant preparation and is specific for tinea cruris and corporis. The only drawbacks are its colour and staining properties. Daily application for 7-14 days will effect a cure and the method is of importance in the treatment of mycotic infections in women. When applied to the feet is may cause drying and fissuring and it may have to be alternated with an ointment. The results in pedal tinea are somewhat disappointing.

2% malachite green in spirit is another useful preparation. It has much the same properties as fuchsin paint and is used in the same way for similar conditions.

Industrial fungicides.

Abracide in the form of an emulsion with soap is extremely popular in some quarters. It is usually employed as a 1/100 bath. In dilutions above this the abracide comes out of solution and floats to the surface. In a series of tests conducted by myself it was found that with the 1/100 solution there was considerable irritation, and that in strengths below this the irritation was confined to the junction of the part under treatment with the surface of the lotion. A 1/100 bath has been advocated as a prophylactic, but this is uneconomic and dangerous.

Paranitrophenol as used in the leather trade is completely non-irritating. Used in a 2% aqueous solution 20 minutes daily for a week, it is of value in tinea pedis and manis. The objectionable yellow colour can be obviated by adding a few drops of hydrochloric acid. On account of the drying effect it should be followed by an ointment. Some workers prefer a 2% solution in spirit.

Mycocten is a favourite remedy in Denmark, and Lomholt

(Goldsmith 1936) advises the following combination:

Mycocten
Ac.salicyl.
Paraf.liq. aa.3 parts
Ung.plumbi ox (D.P.) 60 "

It is frequently employed with a mycocten paint.

Metallic fungicides.

Copper salts in high dilution are lethal to the lower forms of vegetable life, and their use has been logically recommended in mycotic dermatoses. Moloney (1937) reports good results from a 20% solution of dehydrated copper sulphate in pure glycerin. It should be rubbed into the lesion daily for fifteen minutes. Weak solutions of silver nitrate are also useful in the weeping eczematoid type.

Mycotic Extracts.

A considerable amount of work has been done on the use of mycotic extracts in ringworm infections, and the results have been universally disappointing. Even in cases with manifest allergic eruptions it is sufficient to treat the primary lesion. Recently Tolmach and Traub (1938) carried out a carefully controlled series of tests with poor results. In the present state of our knowledge these preparations cannot be recommended for general treatment.

Powders.

Powders are useful in treatment as an adjuvant to ointments. In weeping cases they cause drying of the discharge, and frequently they are all that is required to effect a cure. Burgess recommends -

Boric acid
Venetian talc
Kaolin aa.1 part

Silantox (amorphous silicon dioxide, Silica Gel Ltd.) is another

useful dusting powder (Martin Row 1931). It is best to exclude starch from all powders to be used on the feet. In the presence of moisture and movement it tends to cake and may aggravate itching. As a rule 2% salicylic acid is added to the above preparations.

Sterilisation of clothes.

Whenever possible all garments in contact with the infected area should be boiled. This will include socks, singlets etc. In the case of boots or leather gloves, they should be placed in a box with 50cc. of formalin in an open container and left for 24 hours. To save time the insides of shoes can be swabbed with formalin and left to air for two days. Insoles should be destroyed, and if replaced, they should be sterilised frequently. It may be mentioned that many of the agents employed in dry cleaning are not fungicidal. Kadisch (1931) advises 1% thymol in spirit for sterilising clothes but the method seems unduly expensive. Steam sterilisation is perfectly satisfactory.

Treatment of Tinea Cruris.

If the affected area is inflamed or weeping, calamine lotion, or ichthyol calamine lotion, should be applied three times a day. Some prefer to use ung.hydrarg.ammon. at the start. Under garments should be sterilised at the commencement of treatment and regularly thereafter. When the inflammation has subsided, one of the ointments or paints should then be exhibited daily, or twice daily, according to the reaction of the individual. Later, when a cure has been effected, the area should be dusted frequently with a salicylic acid powder.

This routine is also sufficient for tinea axillaris.

Treatment of Tinea Pedis.

It is essential in all cases of foot infection to ensure adequate ventilation. Woollen socks should be prohibited (Berberian 1938), and cotton or 'cellular' socks worn instead. Rubber shoes are bad as they increase local temperature and humidity, and sandals or shoes with open uppers should be used.

In the presence of a superadded pustular infection, 1/4000 potassium permanganate solution, or 1/5000 perchloride of mercury solution should be used as a bath twice daily, and the feet should be powdered between treatments. When the eczematoid element has been cured, an ointment should be rubbed in. The number of inunctions per day will again depend on the individual reaction. Castellani's paint has a justly deserved reputation in eczematoid ringworms, but it usually requires to be supplemented by an ointment when the case has reached the dry stage.

With salicylic ointments interdigital curettage should be done once weekly and the socks should be boiled frequently. Pedal hyperidrosis if present, must be treated, and the following will be found effective: equal parts spirit vini meth. and water morning and night, or a foot bath of 5% formalin once daily for ten minutes.

Subsequent to cure, regular prophylactic measures, as detailed later, should be carried out.

Treatment of Tinea Unguium.

As the primary focus is in the nail bed, the difficulties in the treatment of nail infections can be appreciated. Undoubtedly the best method is to avulse the nail under local or general anaesthesia and apply anti-mycotic agents to the bed. In most

cases this will suffice, but occasionally it will be necessary to destroy the nail permanently. A more tedious method is to apply liquor potassae and scrape away the softened layer. Whitfield (1934) advises an ointment of 12% benzoic acid and 6% salicylic acid. This should be strapped over the infected parts daily. The nails will come off in about three weeks and as a rule no further treatment is required. Fehling's solution as a daily dressing on lint is useful, and evaporation can be prevented by the use of rubber finger stalls.

Local applications are extremely painful and it may be necessary to use sedative drugs during their exhibition.

Prophylaxis.

Prophylactic measures are of two kinds; those directed towards the individual, and those directed towards his surroundings. Of these the former is to be preferred as the onus is thus placed on the individual. General measures such as interceptor baths, etc. are unsatisfactory by themselves.

Personal.

Firstly, education on foot hygiene is essential. It is astonishing the number of otherwise cleanly people who do not wash the interdigital spaces when bathing, and an equally large number do not bother to dry them properly. This, I consider, is the bases of most pedal mycoses. The natural warmth of the foot and retained moisture predispose to maceration and the soil is thus prepared for infection. In his investigation on U.S. soldiers, Wilson (1934) found that the largest company had the lowest incidence of foot complaints, due to the fact that the company commander took a keen interest in

the welfare of his men. By frequent personal examinations of their feet, he produced a most salutary 'foot fixation' complex in his command. The feet should be kept from contact with the bath-room floor as much as possible, and paper slippers, such as are used in America, are useful.

Notices should be placed in all washing places and showers. To be effective, such notices should be concise, and the following is suggested as a satisfactory poster:-

"YOUR FEET"

"Carelessness in washing and drying the feet
will lead to eczema and ringworm.
Wash carefully between your toes and powder
them after drying.
Report to the doctor at the first sign of trouble".

The feet and interdigital spaces should be washed with soap and water at least once a day, and finally rinsed with cold water to inhibit sweating. They should then be thoroughly dried and powdered with salicylic acid talc, or rubbed with lemon juice (Belisario). Osborne (Goldsmith 1936) advises swabbing the toes with 1% sodium hypochlorite solution, but this seems unnecessary in the face of more simple measures. In hot countries 'ventilated' socks and shoes should be worn at all times. Frequently cramping of the toes is due to shrunken socks, and not, as is usually supposed to ill-fitting shoes.

Cross infection by towels can be prevented by impressing on the individual the necessity for using only his own towel. In humid countries facilities for drying towels after bathing should be provided.

General.

As bath-room floors are generally suspect, they should be

washed frequently with soap and water. Forced ventilation may be necessary to ensure thorough drying. Wooden floors and mats, which cannot be properly cleaned, should be dispensed with and closely set tiles or polished concrete substituted. Rubber mats are useful as they are easily cleaned. Bath stools and benches should be abolished and drying should be done while standing in the bath or shower cubicle. Traffic in the bath-room should be reduced to a minimum.

In the presence of overt infection, walls and floors should be swabbed after washing with 2% sodium hypochlorite solution. Formalin is useful, but the room cannot be used for some time afterwards. A shallow rubber bath containing 1% sodium hypochlorite may be placed at the entrance to the wash-place and bathers made to pass through it. The solution should be changed daily . 5% acidulated paranitrophenol solution is efficacious, but unless the feet are washed before drying the yellow colour reappears on towels. Sodium thiosulphate does not appear to be satisfactory.

Perhaps the best and simplest method is to sprinkle chlorine powder, such as is used for water purification, on the bath-room floor. This soon becomes converted into an adhesive, strongly antiseptic, and thoroughly objectionable mush, and forces the individual to wash and dry his feet carefully. The subsequent washing greatly lessens the risk of a chemical dermatitis. Lastly, large dredgers of salicylic acid talc should be provided and labelled "Foot Powder".

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CHAPTER EIGHT

General Commentary.

In this thesis, an attempt has been made to study the problem of superficial ringworm infections as they affect a large group of men in the second to the fourth decades. Such infections, although usually trivial, can cause great discomfort, and if they reach epidemic proportions the economic loss from disability is apparent. The importance of prophylaxis in institutions, schools, etc., is thus obvious. Many ingenious methods have been devised for mass protection, but I am convinced, and in this I am at one with my more experienced colleagues, that the real approach to the problem of prevention is through the patient. Why is it, that of fifteen men exposed to infection, only one man will contract it, and why is there such difficulty in reproducing the disease experimentally? The answer is obviously in the patient's skin, and if we can render that unsuitable for the growth of fungi, then we have solved the problem.

In the introduction I have pointed out the world wide increase in the incidence of superficial ringworm infections but I take exception to the fantastic figures given by some of the investigators in Chapter 5. To say that 95% of any large group of healthy individuals suffer from pedal mycoses is the veriest nonsense, and is not supported by my own, or by the statistics from the U.S. Navy. A mycotic infection is a state of the skin not a state of the mind, and too many practitioners suffer from what I call "epidermophytosis of the brain".

In Chapter 3 I have endeavoured to set out the routine

methods for diagnosis, and an attempt should be made in all cases to demonstrate a fungus. Frequently a clinically suggestive case will not show fungi, and the trichophytin investigation in Chapter 4 was undertaken with a view to finding an adjuvant diagnostic procedure in such cases. The results were somewhat inconclusive and cannot be relied on by themselves. In this chapter I purposely avoided entering the dreary field of nomenclature in immunobiology. Frequently one reads of fixed and circulating antibodies in ringworm infections, but as far as I am aware, antibodies, as demonstrated by the antigen-antibody precipitation reaction, have never been found in such lesions. Goldsmith had admirably summarised modern opinion on this subject in his Recent Advances in Dermatology.

A knowledge of the viability of the pathogenic fungi is to clinical mycology what pathology is to surgery. Without a clear understanding of the factors influencing the life and growth of the parasite, treatment is purely empirical. I have tried to deal with this fully in Chapter 6.

In the final section no hard and fast routine for treatment is laid down, as I consider that any logical method in careful hands, and under personal supervision, will be successful. It must be remembered, however, that ringworm infections are caused by a delicate vegetable parasite which can remain viable for long periods, and it will be necessary to eradicate possible sources of reinfection in the patient's clothes, shoes, etc., before a case can be pronounced 'fungus free'.